No. VI.] [SECOND SERIES.

THE HOT-BLAST CUPOLA AND UTILIZING CONVERTER FLAME FOR HEATING CUPOLA BLAST.

NOTE.—This Report is printed, not as a publication, but simply for the convenience of my clients, and for their exclusive use.

A. L. HOLLEY.

NEW YORK, October, 1877.

TN715 .H73

TJ 501 .H73

6-16440

HEATING CUPOLA BLAST.

THE chief advantages of the hot-blast for cupola furnaces are:

1st. A notable economy in fuel.

2d. The longer and more uniform working of the furnace, due to the prevention of scaffolding, especially around the tuyeres.

It has long been supposed that the hot-blast would prove as useful in cupola practice as in blast-furnace practice; and although the few experiments in this direction have substantiated the supposition, no attempt has until recently been made to adapt the hot-blast stove to regular cupola work.

Heating the blast by the waste gases of the cupola itself has long been the subject of experiment, and for above a year, of regular practice, by Mr. Alexander Wilson at the Dronfield Bessemer Works near Sheffield.

Utilizing the flame of the Bessemer vessel to heat the cupola blast had been brought to the stage of preliminary drawings last winter by Mr. Arthur Cooper (Bessemer manager) and Mr. C. B. Holland (General Manager), of Messrs. Brown, Bayley & Dixon's Works in Sheffield. It has now been about two months in regular and very successful working at this establishment.

I have postponed giving my clients the data I had about Wilson's cupola until I could also get that about Cooper's im-

provement, so as to present the two together. The accompanying engravings illustrate both arrangements, and I also have detailed working drawings.

The improvement of Bessemer cupola practice assumes still greater interest now that the direct use of blast-furnace metal is as yet hardly making good its early promises. In general foundry practice, the utilization of waste heat in this manner is, of course, a matter of great importance.

WILSON'S HOT-BLAST CUPOLA.

The engraving so well illustrates the arrangement that little description is required. The stove is simply a series of hollow rings, one above the other, connected on one side and on the other alternately, so that the blast will zig-zag as it comes down through them to the belly pipe. The alternate rings are of different diameters, so as to facilitate the impingement of the heating gases against them. The stove is set in the cupola stack. In small cupolas, such as those for spiegel, this stack is enlarged so as to give room for the stove. The cupola gases pass through and around the hollow rings. The thick brick lining of the chamber absorbs heat when the cupola is working hot above, and gives it off to the stove when less gas is burning.

Upon looking into a cupola charging-door just after charging, there does not appear to be flame enough to heat the blast materially, and when the charges are well burned down the heat seems sufficient to destroy a hot-blast stove. But the distillation of carbonic oxide must of course be pretty uniform; when cold materials are thrown on, its combustion is checked, but the gas is coming up just the same. The arrangement Mr. Wilson's experiments have led him to, effectually prevent both the above-mentioned difficulties. By the simple means of a wide fire-brick ledge running around the furnace a short distance above the charging-door, he shields the stove from the direct impact of the flame, and he also forms a combustion-chamber surrounded by hot brick walls, in which the gases, upon being properly mixed with air, will

burn, or rather in which they will always be *lighted*, so that their combustion can go on continuously in the chamber above.

In order that too much air shall not enter when the charging-door is open, the throat leading from the combustion-chamber to the stove is contracted—not so much that the gases tend to puff out of the door, but so that a great volume of air shall not be drawn in. Suitable air-holes are made in the chamber, so that the combustion shall occur below the stove rather than at the chimney-top, as it does when insufficient air is admitted: and so that combustion shall be complete rather than partial and variable, as when a great volume of air rushes in. The air supply may be more perfectly controlled by steam-induced jets. The ledge and also the stove are sustained by wrought-iron brackets imbedded in the lining, and suitable passages conduct a part of the hot gases through the ledge and around the stove.

It will also be observed that the chamber in which the stove is situated is narrowed at the top, so as to prevent the exit of the gases until they have given off their available heat. The blast enters the top of the stove where the gases are coolest, although its direction can be readily reversed, as in Mr. Edward Cooper's hot-blast stoves at Durham, Pa., so as to secure greater endurance of pipes at some sacrifice of heat.

The diameter of the blast-pipe and of the smallest air-passage in the stove is usually 15 in. for a 6 ft. (inside) cupola, but if fan-blast is used the passages should be larger. The bell-mouth joint between the pipes has 4 wedges and a luting of half iron-borings and half fire-clay. The rings are held apart by the joints and by cast-iron distance-pieces. There is, of course, an expansion-joint in the cold-air pipe and a slotted hole in the cupola-shell where it enters.

The following are the principal dimensions, etc., of the cupolas and stoves, working at Wilson, Cammell & Co.'s, Dronfield:

MAIN CUPOLAS.

	Ft.	in.
Height, tap-hole to charging-door........................	15	0
" " lower tuyeres...	3	10
" " upper tuyeres........................	5	4
" charging-door to top of chimney..................	21	0

		Ft.	in.
Diameter, shell of furnace		7	6
" body " inside		6	0
" bosh " "		3	9
No. tuyeres, upper row	6		
Dia. " "		0	2½
No. tuyeres, lower row	6		
Dia. " "		0	5
No. rings in stove	8		
Dia., larger do., over all		5	3
Dia., smaller do., "		4	5
Dia. air-passage in rings		1	3
Thickness bottom rings		0	1½
" top "		0	0¾
Weight of 8 rings	9 tons.		
Heating surface do.	336 sq. ft.		
Cost of apparatus (about)	$1,000.		

SPIEGEL CUPOLA.

		Ft.	in.
No. rings	10		
Dia. larger rings, over all		3	9
" smaller " "		3	3
" air-passage in rings		0	9

Performance.—The temperature of blast coming from a stove with 8 pipes varies from 550° to 600° F., as constantly measured by a pyrometer, and does not vary beyond these limits. A 6-pipe stove heats the air to about 400°. The best number of pipes has not been fully determined. A blue flame at the chimney-top, in the night, would of course indicate that the gas is not completely burned, and that the stove may be enlarged.

The cupola fuel used at Dronfield before the application of the hot-blast was 1 lb. of coke to 7.2 lbs. of iron melted. Since the 8-ring stove was started, it has been 1 lb. of coke to 12.4 lbs. of iron, which is a saving of *nearly forty-two per cent. of fuel.*

The melting capacity of the cupola has also been increased nearly twenty per cent.

The charging is as follows: 3 tons of pig and 4¾ cwt. of coke, 30 times per 12 hours, yielding 90 tons per turn.

One of these stoves had been running some seven months in March last, when I saw it, and it appeared to be as good as new. I am informed that it has since required no repairs.

Six of the stoves are working at Dronfield, and I learn that the improvement has been adopted at the Penistone and other Bessemer works, and in a number of foundries.

This arrangement seems admirably adapted to the purpose. It is cheap, simple, compact and durable; the stove may be hoisted out of the top of the stack, and quickly replaced; the facilities for combustion are good; the opportunity for circulation of gases around the stove is ample, and the area for the blast may be made indefinitely large. These advantages are capable of accounting for the high economy and durability which are realized.

To apply the apparatus, no change in the cupola proper is needed, and no room is required other than that, or about that, which the ordinary stack occupies. But, simple as the arrangement appears, it has, like other simple and effective appliances, required much contrivance and experimenting.

It has been suggested that, by simply raising the cupola, the waste carbonic oxide would be utilized in heating the stock, and so preparing it for more rapid melting, and that thus the cost of air-heating apparatus would be saved. The trouble is, however, that the waste gas will not heat the stock, nor anything else, until it is set on fire. To do this by injecting blast much above the main tuyeres would be (as has been proved by experiment) to make another melting zone, and to stop the free and continuous working of the furnace. Making Bessemer cupolas 5 or 6 feet higher, as will be shown further on, is economical; for a good deal of gas is burned to waste in our present low furnaces; but the only way to completely utilize the gas in a *melting*-furnace, the conditions of which are entirely different from those of a smelting-furnace, is to burn it above the charges, and apply its heat outside of the furnace proper.

COOPER'S BLAST-HEATING BY WASTE VESSEL FLAME.

The engraving of this apparatus fully illustrates its application to two adjacent vessels as arranged in English works. The same arrangement, substantially, may be readily applied to the American plant.

It is simply a pipe-stove placed in a brick chamber in such manner that while the vessel-flame need not impinge directly upon the pipes, the hot products of the flame come in contact with them and give up their heat to them. The air for the cupolas is passed through the stove.

The flame from vessel A diffuses itself in stack C (Figs. 1 and 2), which is covered and closed as a damper, I; the hot gases must thence pass into the pipe-chambers or stove, D, E, and F (Fig. 2), and finally into the stack, G, and off through the damper, H. When vessel B is at work the direction of the gas is reversed, the stove being common to both.

The thick brick walls of the stacks and stove form a sort of regenerative chamber, and, both dampers being nearly closed, give off much heat to the pipes when neither vessel is blowing. When no air is passing through the stove, the damper over the vessel in use is opened, so as to prevent burning the pipes.

It will be observed that, without necessarily following this exact plan, a large stove may be placed common to the two vessels, in such a way that flame will not play directly against the pipes, but so that a volume of highly-heated gas, larger than the volume of air delivered by the blowing-engine, will give up its heat to the pipes: and also that while the vessels are not blowing, a draft of hot air will surround the pipes. In other words, a stove arranged in this way—the value of Mr. Cooper's invention lies in the *arrangement*—may be made at once durable and effective. It has heretofore been thought that vessel-heat was too fitful to be utilized, but the results to be mentioned prove quite the reverse.

At Brown, Bayley & Dixon's works, in Sheffield, this apparatus has been in use since the middle of August last. There is a blow once an hour from one vessel or the other. During the blow the cupola blast is heated to 500° F., and just before the next blow it has fallen to 400°. This fall of temperature would hardly occur at all in American works, where the blowing is almost continuous.

I have appended the official record of the four weeks comparative performance of hot and cold blast cupolas, just as I received it.

"*Pig iron melted and coke consumed during the four weeks ending September 22, 1877, in Bessemer B with ordinary cold-blast, and in Bessemer A with blast heated by apparatus recently constructed between No. 2 vessel, Bessemer A, and No. 1 vessel, Bessemer B.*

BESSEMER B CUPOLAS, COLD BLAST.

	Total Pig Iron Melted.			Total Coke Consumed.			Coke per ton of Pig Iron.
Weeks ending	Tons.	c.		Tons.	c.		cwts.
1st September	813	4	..	93	..	1	2.287
8th "	829	12	..	82	16	..	1.996
15th "	915	8	..	83	14	..	1.830
22d "	883	10	..	84	18	3	1.930
Total . .	3441	14	..	344	9	..	2.000

BESSEMER A CUPOLAS, HOT BLAST.

	Total Pig Iron Melted.			Total Coke Consumed.			Coke per ton of Pig Iron.
Weeks ending	Tons.	c.		Tons.	c.		cwts.
1st September	924	..	..	69	13		1.507
8th "	852	8	..	63	5	2	1.551
15th "	1014	10	..	70	13	2	1.391
22d "	977	10		77	5	1	1.580
Total . .	3768	8	..	280	17	1	1.490

"*Therefore the saving effected in coke by the use of hot-blast during the above four weeks, ending September* 22, 1877, *has been as follows :* 2.00 *cwts. less* 1.49 *cwts.* = .51 *cwts. of coke per ton of pig iron melted ;* 3,768 *tons of pig iron at* .51 *cwts. coke per ton* = 96 *tons of coke ;* 96 *tons of coke at* 19*s.* = £91. *This is at the rate of* £1,137 *per shop per annum.*"

Within a few days I have received the following results:

WEEK ENDING SEPT. 29, 1877.—837 tons of pig iron have been melted with 63*t.* 2*c.* 0*qrs.* of coke, or 1*c.* 2*qrs* 0¾*lbs.* coke per ton of pig iron.

FIVE WEEKS ENDING SEPT. 29, 1877.—4,605.4 tons of pig iron have been melted with 343*t.* 19*c.* 1*qrs.* of coke, or 1*c.* 1*qrs.* 27¼*lbs.* coke per ton of pig iron.

The following is a brief analysis of the results given in the tables:

COLD BLAST.

Lbs. iron melted with 1lb coal	10

HOT BLAST.

Lbs. iron melted with 1lb. coal	13.4
Saving of coal by means of hot blast	34%

This saving is not quite as large as that made at the Dronfield works, but it must be remembered that the latter started with an inferior practice, viz., 7.2 to 1, upon which it was easier to improve; and that Brown, Bayley & Dixon have reached a higher economy, viz., 13.4 to 1 against 12.4 to 1 at Dronfield.

The old practice at Brown, Bayley & Dixon's was, before the application of the hot blast at either place, superior to that at Dronfield and elsewhere in England, for the following reasons: The cupolas had been raised from 14 to 21 feet in height. The hearth is 5 ft. in diameter and 5 ft. deep from the lower tuyeres (3 five-inch tuyeres); the upper tuyeres, of the same size, are 15 in. higher, and the diameter of furnace is narrowed at this point to 4½ ft. The blast is ¾ lb.

The cupola lining is stone, and will stand melting about 600 tons in the weakest place.

I am further informed regarding Brown, Bayley & Dixon's practice, 1st, that with the hot-blast "the tuyeres are always bright, and there is no scaffolding above them"; 2d, that "the apparatus is in as perfect working order as it was on the day it started"; 3d, that there is yet no brick-lined main from the stove to the cupolas, and that much heat is thus wasted; and, 4th, that at a late meeting of the directors it

was determined to erect a brick-lined main, and to at once apply the apparatus to all the other vessels.

Conclusion.—Here are two methods of treating cupola blast by waste heat; they both give about the same economy, and it is a very substantial economy. The apparatus in both cases is simple, durable, and not expensive. That one or the other should be adopted generally in American works is too evident to require discussion. May not the two be united? A pyrometer in the vessel stack at Brown, Bayley & Dixon's showed the average general temperature to be 1,200° F., and the maximum to be 1,400°, which is probably much higher than that in the cupola stack. If this vessel-heat were stored and equalized by a mass of fire-brick—possibly heavy checker-work—surrounding the pipe-stove, it might add some hundreds of degrees to the temperature of the blast after it had left the cupola stove.

It has certainly been proved that a very large amount of heat from the vessel-flame may be saved and utilized, without danger to the apparatus, by means of the arrangement worked out by Mr. Cooper. Applying this heat to feed-water would evidently not be impracticable.